



## Original Communication

## Morphometric features and sexual dimorphism of adult hyoid bone: A population specific study with forensic implications

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## ARTICLE INFO

## Article history:

Received 21 October 2009

Received in revised form

18 February 2010

Accepted 1 April 2010

Available online 5 May 2010

## Keywords:

Forensic anthropology

Personal identification

Sexual dimorphism

Morphology

Hyoid bone

Indian Bengali

## ABSTRACT

Hyoid is a U-shaped bone present in the ventral aspect of neck at the level of fourth cervical vertebra. Morphological variants of hyoid are well documented. The present study was designed to identify these morphological features and examine the sexual dimorphism of adult hyoid bone in Indian Bengali population. The present work consisted of direct measurement in autopsy cases in a population specific sample. It was observed that the hyoid was larger in males regarding width, antero-posterior length and slope of cornu. Using *t*-Test with alpha level of 0.05 the length of greater cornu was found to be the only variable not significantly different in the two sexes ( $p = .116$ ).

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## 1. Introduction

Hyoid is a U-shaped bone present in the ventral aspect of neck at the level of fourth cervical vertebra. It is a small bone placed between the root of tongue and the thyroid cartilage. The hyoid gives attachment to several muscles and ligaments of the neck. Anatomically the hyoid is composed of a body, two greater cornua and two lesser cornua. Each cornu is attached to the body by synchondrosis that calcifies with ageing. The tip of the cornu are directed postero-laterally. The important attachments of the hyoid are myelohyoid, omohyoid, thyrohyoid and stylohyoid.<sup>1</sup>

Morphological variants of hyoid are well documented. Mainly the U-shaped and V-shaped hyoid is differentiated on the basis of the angle subtended between the cornu (extended). 25 degrees is the demarcating value according to a study on Croatian population.<sup>2</sup> Several works have established sexual dimorphism of various skeletal components.<sup>3,4</sup> Recent studies on India population have examined different skeletal markers of sexual dimorphism.<sup>5–7</sup> Sexual dimorphism of hyoid has also been established.<sup>8</sup> In the males V-type and in the females U-type hyoid bones were the leading types that covered 1/3rd of specimens<sup>9</sup>

Significant sexual difference was found in U and V types of bones ( $p < .025$ ,  $p < .05$ ).

An image analysis system was used in a study<sup>10</sup> by taking a series of 30 measurements on digitized radiographs of 315 hyoid bones from people of known age and sex. They had shown that there is a continuous distribution of hyoid bone shapes and that most bones are highly symmetrical.

There are several postulates where polymorphism in hyoid is related to sex and race. This further warranted population-based studies on hyoid. Another study<sup>11</sup> focused on sex-based morphometry of the hyoid bone in Koreans using digital photographs. The accuracy of discriminant functions was 88.2% in both groups, proving that those could be used to distinguish males from females in a statistically significant manner.

The hyoid bone is an important structure of the neck that has forensic significance. Injury to the hyoid is commonly encountered in compressions of the neck (hanging and strangulation.) The slope and curvature of the hyoid bone were contributing factors for fracture hyoid in strangulation.<sup>12</sup> Age related changes of hyoid<sup>13</sup> are also equally important in forensic pathology.

Besides direct trauma to hyoid are also reported in road traffic injuries. Often the hyoid bone is found in unidentified decomposed bodies where the age and sex of the individual is under scrutiny. The present study was designed to identify these morphological features and examine the sexual dimorphism of adult hyoid bone in Indian Bengali population.

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## 2. Materials and method

A prospective study on autopsy cases was conducted at the mortuary of the department of Forensic Medicine, Burdwan Medical College, Burdwan, West Bengal, India. Initially the author examined (at autopsy) 100 consecutive cases of hanging deaths in adult subjects (above 18 years of age). The closing age of the sample was 75 years. Cases with other injuries over neck, fractured hyoid and decomposed corpses were excluded. All the cases were examined (autopsy) within 24 h of death. Of these 100 autopsies 84 fulfilled the inclusion criteria and were considered in the study. Of those 84 hyoids 28 were male and 56 were female.

Subsequently to homogenize the sample as to cause of death and sex we included 30 male hyoids from consecutive medico-legal autopsies. Thereafter 15 consecutive female and male hyoids each were added using the same inclusion criteria. So the sample finally comprised of 144 hyoids. In the present study sample of 144 intact adult hyoid bones 73 were male and 71 female.

At complete forensic autopsy, the hyoid in all the cases were carefully dissected using a V-shaped incision of the neck. The brain and chest cavity were opened and drained to minimize the chances of artifacts and the hyoids were dissected. Soft tissue was removed, with minimal handling. Hyoids were then kept in 10% formaldehyde solution for 72 h. This was followed by further cleaning, removal of tags and wiping dry.

Direct measurements were taken by technical quality divider and metallic (steel) graduated scale with readings up to 1 mm. Three readings were taken and average of the results were recorded. All measurements were taken keeping the bone on flat surface in anatomical positions.

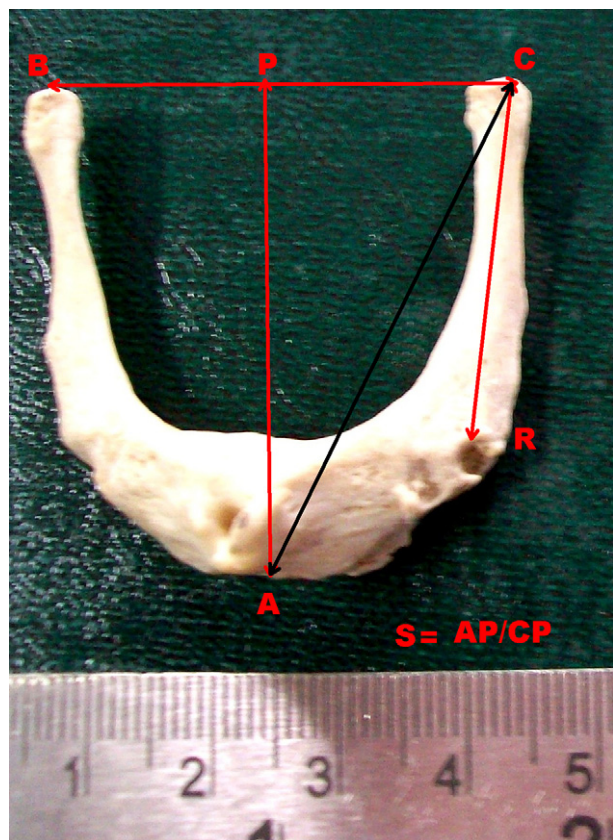


Fig. 1. Showing the morphometric variables used in the study. Width (BC); Anteroposterior length (AP); Length of greater cornu (CR); Slope of cornu (S).

Table 1

Summary statistics of age of the sample and results of *t*-Test.

Sex	Number of hyoids	Mean age (years)	Standard deviation	Standard error of mean	
Female	71	36.31	13.59	1.61	$t = .785$
Male	73	34.64	11.84	1.39	$p = .434$

The following measurements were taken (see Fig. 1 for details).

- (1) Width or breadth of hyoid (BC): distance between the distal ends of the greater cornua (horns).
- (2) Length (AP): distance in the antero-posterior plane from the anterior middle of the body of hyoid to the point lying mid-way between the tips of the greater horns.
- (3) Length of Cornu (CR): distance from the junction of cornu and body to the tip of greater cornu. (Left side, recorded in mm).

Metric data was summarized as mean, standard deviation, standard error of mean, median and 95% confidence interval. To compare between mean of the two unpaired groups, student's *t*-Test was used taking *p* value of  $<.05$  as significant (two-tailed *p* value).

The *t*-Test for independent sample is a parametric test to examine the difference in the means of the variable under study between two unrelated groups. This test assumes that the variable is normally distributed. The other assumption is the equality of variance. The null hypothesis ( $H_0$ ) is that there is no difference in the means of the variable between the two groups. The *t* statistic is calculated and the corresponding *p* value is obtained. If the *p* value is less than the pre-defined alpha level (in this case .05) we can reject the null hypothesis. Rejection of the null hypothesis implies we can accept that there is a significant difference in the means (of variables used in the analysis) of the two groups (male and female hyoids in this case). In other words the difference in the means of the variable between the two independent groups is not by chance. Statistical analysis was done using SPSS software version 10.0 for windows.

## 3. Observation/result

Summary statistics of age is seen from Table 1. Mean age at death of the male subjects was 34.64 and for females it was 36.31 years. The standard deviations (SD) for male and female were 11.84 and 13.59 respectively. There was no significant difference in age between male and female subjects examined in the present series (*p* value equals to .434). Taking both the sexes together the minimum age was 18 years while the maximum was 68.

From Tables 2 and 3 it was seen that there was no significant difference between cornual length of right and left sides of the hyoid bones. Of the 144 hyoids 134 had equal length of cornu on both sides. The difference was noted in only 10 hyoids (6.9%). The

Table 2

Summary statistics of cornual length of right and left side and results of paired sample *t*-Test.

Variable	Mean length in mm	Standard deviation	Standard error mean	Correlation coefficient	Paired sample <i>t</i> -test
Cornu of left side	21.74	1.48	.1236	.980	$t = -1.474$
Cornu of right side	21.78	1.47	.1221		$p = .143$

**Table 3**

Distribution of the hyoids on basis of symmetry.

Type of hyoid	Frequency	Percent
Symmetrical	134	93.1
Asymmetrical	10	6.9

difference was not statistically significant as found from results of paired sample *t*-Test ( $t = -1.47$ ;  $p = .143$ ).

The dimension of the hyoid in male and female subjects is seen from Table 4. The table shows the descriptive statistics of the parameters used in the study. It was observed that the hyoid was larger in males regarding all three variables. Mean width in females was 37.15 (SD = 3.92) and in males it was 40.65 (SD = 3.42) mm. The mean antero-posterior length was 22.32 (SD = 2.09) in females and 29.63 (SD = 3.96) in males. The mean slope (Fig. 1) of cornu (axis subtending angle with horizontal) in female hyoids was 1.21 (SD = .154) and in males it was 1.46 (SD = .185). The length of greater cornu was 21.55 (SD = 1.72) in females and 21.94 (SD = 1.20) in male hyoids.

Table 4 also shows the test of significance of the difference of the means by *t* statistic and the corresponding *p* value. The male hyoids were wider than female hyoids ( $t = -5.71$ ;  $p = .000$ ) showing strong statistical significance. In males the hyoids were also longer significantly ( $t = -13.8$  and  $p$  value = .000). The lengths of greater cornu in the male hyoids were more than in females. But this difference was not statistically significant ( $t = -1.58$ ;  $p = .116$ ) as shown in Table 4. The slope of the cornu was more in males than females with strong statistical significance ( $t = -8.76$ ;  $p = .000$ ).

#### 4. Discussion

Earlier works have shown that metric analysis of the hyoid bone is a helpful technique in the sex determination of a skeleton.<sup>8,9</sup> In both sexes considerable increase in measurements was noticed till the age of 13 years in a study on north Indian population. The said study<sup>9</sup> had also revealed that most of dimensions increased further till the age of 35 years in males and 17 years in females and remained unchanged thereafter. Sexual differences were insignificant up to the age of 13 years. With a single parameter e.g. length of greater cornu, the width of body and weight of the bone, the sex could be determined in 11 percent to 37 percent bones. Sexual dimorphism in the hyoid bone has been investigated earlier using 13 measurements taken directly from the X-ray film. The anthropometric measurements of the hyoid in the present series (Indian, Bengali) are comparable with those of a Croatian study on 70 hyoids.

In the present study it was observed that the hyoids in the male were wider than those in females. There was extremely strong statistical significance ( $t$  value =  $-5.71$  and  $p$  value of .000). Earlier

works from Indian sample are in consonance with the present results. This however, is contrary to another earlier work where no significant difference was seen in case of strangulations using xeroradiography in a series of 20 cases.

Hyoids in male were significantly longer (antero-posterior length) than those in female ( $t = -13.8$ ;  $p = .000$ ). This extremely strong statistical significance is in consonance with earlier studies.<sup>10,11</sup>

In the present series no significant difference was found between lengths of the left and right cornu. Majority (93.1%) of the hyoids were symmetrical. This is in consonance with earlier study on Indian population. Morphologically asymmetry, which has been discussed by earlier researchers<sup>12</sup> as a contributing factor for fracture was not found in the sample under study.

The slope of the axis of the greater cornu (hypothetical line subtending an angle at the horizontal plane) was also considered as a morphometric variable. The value was calculated by the ratio between the length (antero-posterior distance) and  $\frac{1}{2}$  of the width of hyoid or the tangent of the subtended angle (Fig. 1). The mean ratio for the male hyoids was 1.46. The means of the above ratio of the two groups differed significantly. The slope and curvature of the hyoid bone were contributing factors for fracture hyoid in strangulation as noted by early workers.<sup>12</sup> There was no significant association between age and slope (Pearson's correlation coefficient = .077;  $p = .35$ ). Interestingly on controlling for sex there was significant negative correlation between age and length of greater cornu (partial correlation coefficient =  $-.193$ , degree of freedom 141;  $p = .021$ ). This factor could be studied further to explain the differential percentage of fracture of hyoid in elderly males. This finding of the present work is in consonance with previous works asserting the association of morphological change in hyoid with ageing.<sup>13</sup>

There was no statistically significant difference in length of the cornu in the two sexes. This is overtly contrary to earlier works where analysis of sexual dimorphism showed that the greatest length differences were in the greater cornu. The greater cornu is often inclined slightly at the junction with the body (which may or may not be calcified) this factor was overlooked in the present study for the purpose of simplicity of measurement in the present work. This can be overcome in future study designs.

The present work consisted of direct measurement in autopsy cases. We believe this to be more accurate and reliable than other earlier works of morphometry with xeroradiography and digital measurements.<sup>11,12</sup> No correction factors for measurement (distance of x-ray film and orientation) were needed. Workers who have used direct measurement as method of choice support this view.

The present work was conducted with direct measurement of only three variables. Further research with a larger study design and more number of measurable morphometric variables should be done to arrive at some quantitative index to discriminate between male and female hyoid. Morphological variations related to race and population can be worked out using population-based studies. Using digital measuring instruments can increase the precision of

**Table 4**

Showing the sexual dimorphism of hyoid bone (results of statistical analysis).

		Mean	Standard deviation	Standard error of mean	Number	Statistic*: <i>t</i> -test	
						<i>t</i>	Significance
Width (BC)	Female	37.1549	3.92	.4660	71	-5.71	$p = .000^{**}$
	Male	40.6575	3.42	.4008	73		
Antero posterior length (AP)	Female	22.3239	2.09	.2479	71	-13.8	$p = .000^{**}$
	Male	29.6301	3.96	.4631	73		
Length of greater cornu (CR)	Female	21.5493	1.72	.2036	71	-1.58	$p = .116^{***}$
	Male	21.9384	1.20	.1400	73		
Slope (S)	Female	1.2127	.154	1.836E-02	71	-8.76	$p = .000^{**}$
	Male	1.4616	.185	2.159E-02	73		

\**t*-Test;  $p$  value of  $<.05$  as significant (two-tailed); degree of freedom = 142; \*\*significant; \*\*\*not significant.

the measurements. This is an accepted shortcoming of our work, as we could not afford those.

This is a humble attempt at studying the morphometric features and sexual dimorphism in adult hyoid bones in a population specific sample (Indian Bengali). Morphologically the hyoids showed sexual dimorphism in the study sample. Of the three variables only the length of greater cornu was not significantly different in the two sexes. This, being a preliminary study, would be of help to design further work on the age related changes of hyoid in the two sexes and its forensic significance.

#### **Ethical approval**

Not applicable as no human subject was involved. Autopsy procedure is done according to a statutory order in all unnatural deaths.

#### **Source of funding**

None.

#### **Conflict of interest**

None.

#### **Acknowledgement**

I thank the anonymous reviewers for their constructive criticism and valuable suggestions for improving the paper.

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